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## Battlefield Information Systems Technical Area

## 1986-1987



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United States Army Research Institute for the Behavioral and Social Sciences

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15. SUBJECT TERMS

Morse Code performance, high information density displays, JSTARS MOS analysis.

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Hyman, A. (1986). Test-bed for high information-density displays: A war-room in a tank. WP BIS 86-01.

Knapp, B.G. (1986). JSTARS MOS analysis for Army aircrew. WP BIS 86-03.

Knapp, B.G. (1987). JSTARS ground station module MOS analysis. WP BIS 87-01.

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# Working Paper 87-06

## COMPARISON OF RATING SCALE METHODS FOR APPLICATION IN DISCRIMINATING 05H (MORSE INTERCEPT OPERATOR) PERFORMANCE

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# COMPARISON OF RATING SCALE METHODS FOR APPLICATION IN DISCRIMINATING O5H (MORSE INTERCEPT OPERATOR) PERFORMANCE

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## Overview

The project described herein is part of an ongoing research effort by the Intelligence Research Group within the Systems Research Laboratory at ARI. This group is concerned with the measurement and assessment of military intelligence personnel, the results being utilized for the improvement of systems design and training procedures.

## Introduction

As part of its continuing efforts to improve efficiency, the US Army Intelligence School-Devens (USAISD) seeks to reduce the attrition in its Morse code intercept operator course (MOS O5H). Asked by USAISD to assist, the Army Research Institute (ARI) developed a psychological test battery and rating scales to characterize O5H performance. This profile may eventually be utilized to select personnel who are likely to succeed during O5H training and in the field. It may also function to point out weak or missing areas in the current training program which can then be revised and strengthened. This paper describes the review and selection process undertaken to develop the rating scales for this project.

The ARI O5H psychological profiles project required the development of two separate rating scales. The first scale was

to determine the degree of association between O5H instructor ratings (of students in the O5H training course) and success/failure of students in the O5H course. The second rating scale was administered to O5H supervisors to obtain evaluations concerning the quality of on-the-job performance of individual O5H operators. One of the constraints in developing the scales was that time to administer the scales in the operational setting was limited, therefore options for the types of scales to be considered were guided by this criterion.

## Method: Comparison of Rating Scale Methods

Three scaling methods were reviewed from the pertinent literature (Schwab, Heneman, DeCotiis, 1975) which appeared appropriate for use in assessing O5H performance: Behaviorally anchored rating scales (BARS), behavioral observation scales (BOS), and graphic rating scales (GRS).

### BARS

For the BARS, while there are minor variations in the procedure employed, scale development normally includes five stages. The first is the identification of critical incidents. Individuals who are knowledgable of the job to be investigated (job holders and/or supervisors) are asked to provide specific examples of effective and ineffective job performance behavior. The second step involves clustering the obtained incidents into a smaller set of performance dimensions, which are typically defined also. Then a second group of job experts are asked to retranslate the critical incidents. In other words, they are

given a list of the performance dimensions and the behavior examples and asked to assign each incident to the dimension which best describes it. This step helps determine which incidents will be included in the final scale. An incident is retained if some percentage of the group (usually 50-80%) assigns it to the same dimension as did the group in the second step. This second group is usually also asked to rate each behavioral incident on how effectively or ineffectively it represents performance on the appropriate dimension. The average rating assigned (on a 7- or 9-point scale) indicates the degree to which the incident describes effective performance and the standard deviation represents the amount of agreement among raters regarding the effectiveness level described by the incident (the lower the standard deviation, the greater the agreement). A standard deviation cut-off is then set (normally 1.50 and less) for deciding which incidents will be retained for the final instrument. The final BARS instrument consists of a series of scales, one for each dimension, anchored with the retained incidents.

There is some disagreement in the literature (Jacobs, Kafry _Zedeck, 1980) concerning the psychometric properties of behavior-based scales, like Behaviorally Anchored Rating Scales (BARS) and Behavioral Observation Scales (BOS), compared to other rating scale methods. Researchers have hypothesized that halo error would decrease with the BARS due to more clearly defined performance dimensions and that leniency error would decrease because levels of performance are clarified. Some studies (Campbell, Dunnette, Arvey

Hellervik, 1973; Borman _Dunnette, 1975; Keaveny _McGann, 1975; Finley, Osburn, Dubin _Jeanneret, 1977) have reported superiority of BARS over other scales with respect to halo and leniency errors. However, several researchers (Burnaska Holloman, 1974; Bernardin, LaShells, Smith _Alvares, 1976; Bernardin, 1977) found no differences between rating formats. Others (Borman _Vallon, 1974; Saal _Landy, 1977) showed the BARS to be inferior to other scales on leniency and halo. Similarly ambiguous results were found on interrater reliability (typically ranging from .52 to .76) and ratee differentiation of the BARS.

BOS

The description and construction of the Behavioral Observation Scale is similar to the BARS in many aspects. The BOS also requires experts to identify the critical observable behavior incidents as they relate to performance and assign them scale values indicating effective or ineffective performance. But instead of asking the rater what the ratee is expected to do (as in the BARS), the BOS asks how frequently a ratee has been observed performing a particular critical behavior (on a 5- or 7-point scale). The logic is that a better worker will more frequently engage in behaviors critical to job success than poorer performers. Evaluation of a ratee's performance on a particular dimension is derived by summing the frequency ratings of each behavior in that dimension.

Behavioral Observation Scales have been proposed by Latham and Wexley (1977) to be a useful performance appraisal tool.

Even though psychometric comparisons between BOS and other rating scales have been inconclusive (Bernardin Kane, 1980), BOS has been recommended because of its simplicity. It appears to simplify the rater's task by focusing on the observation of ratee behavior, whereas judgemental rating scales involve more complex and often unreliable judgements about performance. While logical, problems have arisen with this hypothesis. A study by Murphy, Martin, and Garcia (1982) suggests that the recall of ratee behavior is not a simple automatic process, but instead the decisions about the frequency of observed behaviors over a span of time are formulated by judgements, general impressions, and inferences.

GRS

The description and construction of the Graphic Rating Scale is much simpler than that of the BOS or BARS. There are numerous variations of the GRS, but these scales mainly differ in three ways: 1. the degree to which the meaning of the response catagories are defined, 2. the degree to which the person who is interpreting the ratings can tell what response was intended, and 3. the degree to which the performance dimension being rated is defined for the rater. Some scales use qualitative end anchors, some use numerical and verbal anchors, and some use only verbal anchors. Occasionally relevant performance statements are used to anchor the GRS, but these are subjectively chosen by the developer and do not go through a rigorous selection process like that for the BOS and BARS.

Compared to the BOS and BARS, the GRS is inexpensive, quick and easy to develop. It is also a standardized scale and is therefore comparable across individuals. The imposing disadvantage of the GRS is that by giving maximum control to the rater, it generally provides less control for leniency, central tendency, and halo errors. Much of the above noted research compared behavior-based scales with GRS and obtained ambiguous results. In numerous studies, the behavioral scales out-performed the GRS, but in other instances no differences were detected between the two methods.

## Recommendations _Application:
## Selection of Scales for O5H Development

Despite some arguments against the BARS and BOS, relating to incidents of higher halo and leniency error, they both have many practical considerations which make them appealing choices. Wiersma and Latham (1986) emphasized the importance of the practicality of a scale. The results of their study indicate that both supervisors and subordinates prefer behaviorally anchored scales, particularly BOS. In this respect, "to the degree that an appraisal instrument is not acceptable to the user, it will not be used properly" (p. 619). The BOS was preferred because it minimized personality disputes, improved rater-ratee feedback, allowed raters to justify low ratings and was more defensible in court than the other rating methods. A study by Silverman and Wexley (1984) found that the extensive involvement of employees and supervisors in development of the BARS can result in more positive reactions by workers to the performance appraisal interview as well as subsequent outcome measures.

As a result of the literature review above and given the constraint stated that the selected scales must be administered in a timely fashion, a Behavioral Observation Scale was developed to be employed by 05H instructors, and a Behaviorally Anchored Rating Scale was developed for use by 05H supervisors. These scales are presented in Appendix A. While modifications in the development of the BOS and BARS were necessary due to SME (subject matter expert) data availability, these methods proved to be the most useful for the stated purpose of characterizing 05H performance. In developing the BOS for the instructors, information was obtained from 25 current 05H instructors from the US Army Intelligence School-Devens (USAISD) describing behaviors critical to the success/failure of 05H students. Scales representing the critical aspects of the job were developed and presented in such a way that the rater was to indicate the frequency with which each behavior was actually observed. Table 1 lists example 05H performance dimensions and the critical incidents on the BOS related to them.

The BARS was developed in a manner similar to the BOS. Critical incidents of on-the-job 05H operator behavior were collected from and evaluated by 12 05H supervisors obtained from USAISD and US Army Intelligence and Security Command (INSCOM). The retranslation of the critical incidents was performed in-house. Table 2 provides several examples of the types of incidents used. As an additional check on the content validity of both the BARS and the BOS, essentiality ratings were obtained from numerous pilot subjects. This involved the rater providing a rating of how essential each item on the scale

was to the task in question. In conjunction with the psychological test battery being administered to O5H personnel, the rating scales provided the needed quantification of judgmental data regarding student and operator performance.

## Summary

The rating scales developed were used as one component of the ARI O5H operator and student profiles effort to aid in reducing AIT attrition. Approximately 100 O5H operators and 100 students have been assessed using the scales. Reports containing these findings will be detailed in ARI Working Papers 87-07, O5H Operator Profile and 87-08, O5H Student Profile (Knapp et al, 1987).

In general, behavior-based rating methods can be seen as an extensive job analysis. The job responsibilities/behaviors necessary for effective O5H performance were clearly defined during the development of the scales. This information delineates the critical skills which could be translated into a training program. According to Jacobs et al, 1980, BARS use as an evaluative tool in performance appraisal needs to be expanded to become an essential element of a total performance evaluation system. It is particularly in this light that the BARS and BOS were chosen as the rating methods for the O5H effort.

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Performance In Training:

* Student maintains a consistent code copy rate throughout a day (i.e. consistent passing or failing rate).

* Student maintains a consistent code copy rate throughout the course (over numerous weeks).

Motivation/Self-Discipline:

* Student takes responsibility for his/her own performance (i.e. does not "give up" or make excuses for poor performance).

* Student monitors his/her own course progress (i.e. inspects hourly roster of scores posted or asks instructor).

Attention/Effort:

* Student is attentive toward the instructor (i.e. establishes eye contact; asks questions).

* Student displays effort to do well in the course (i.e. seeks assistance/feedback from the instructor to improve performance).

Table 1. Examples of 05H Performance Dimensions and Critical Incidents

* Displays the knowledge/skills required to perform most job assignments and tasks properly, but may need help for harder tasks.

* Puts in the extra effort and keeps trying when it's very important to complete assignments; overcomes obstacles/adversities on the job, in garrison and in the field.

* Completes intercept forms and logs, and reports with few errors; helps in facilitating follow-up processing and analysis.

* Performs collector analysis adequately, often noticing suspect items of intelligence interest; makes few computer generated errors that can be attributed to the operator.

Table 2. Example critical incidents in the BARS

# APPENDIX A

O5H INSTRUCTOR SURVEY

O5H SUPERVISOR SURVEY

# O5H Instructor Survey

Instructor's Name: ________________________________
Student's Name: __________________________________

PERFORMANCE IN TRAINING:

*Student maintains a consistent code copy rate throughout a day (ie. consistent passing or failing rate).

Almost Never 1 2 3 4 5 Almost Always

*Student maintains a consistent code copy rate throughout the course (over numerous weeks).

Almost Never 1 2 3 4 5 Almost Always

*Student copies 100% of all messages sent (regardless of errors).

Almost Never 1 2 3 4 5 Almost Always

*Student diligently copies code a greater percentage of the hour relative to the other students.

Almost Never 1 2 3 4 5 Almost Always

MOTIVATION/SELF-DISCIPLINE:

*Student takes responsibility for his/her own performance (ie. does not "give up" or make excuses for poor performance).

Almost Never 1 2 3 4 5 Almost Always

*Student is present for class and on time each day.

Almost Never 1 2 3 4 5 Almost Always

*Student monitors his/her course progress (ie. inspects hourly roster of scores posted; asks instructor).

Almost Never 1 2 3 4 5 Almost Always

*Student seems to provide his/her own motivation - either a positive "pat on back" or negative "kick in pants" (ie. does not require the instructor's motivation).

Almost Never 1 2 3 4 5 Almost Always

ATTENTION/EFFORT:

*Student is attentive toward the instructor (ie. establishes eye contact; asks questions).

Almost Never 1 2 3 4 5 Almost Always

*Student reads and follows instructions (ie. consistently from the start of the course; takes 2-3 weeks to realize the importance of of instructions).

Almost Never 1 2 3 4 5 Almost Always

*Student is attentive toward the task at hand (ie. hunches determinedly over the keyboard while copying code; slouches back in a relaxed, unhurried position).

Almost Never 1 2 3 4 5 Almost Always

*Student displays effort to do well in the course (ie. seeks assistance/feedback from the instructor to improve performance).

Almost Never 1 2 3 4 5 Almost Always

SOCIAL BEHAVIOR:

*Student engages in social activities with his/her peers outside the classroom (ie. travels downtown on weekends; engages in sports, hobbies; or is a "barrack rat").

Almost Never 1 2 3 4 5 Almost Always

*Student engages in thrill-seeking, outrageous behavior inside or outside the classroom (ie. "practical jokes" requiring disciplinary action, etc.).

Almost Never 1 2 3 4 5 Almost Always

Name: ________________________

# 05H SUPERVISOR SURVEY

## TECHNICAL KNOWLEDGE/SKILL:

How effective is each operator in displaying job knowledge/skill?

| Does not display the knowledge/skill required to perform many job assignments and tasks. | | Displays the knowledge/skill required to perform most job assignments and tasks properly, but may need help for harder tasks | | | Displays the knowledge/skill to perform all job assignments and tasks properly. | | |
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EFFORT:

How effective is each operator in showing extra effort on the job?

| | Does not put in the effort to make sure the job gets done; may give up easily when faced with difficult problems or situations. | | Puts in the extra effort and keeps trying when it's very important to complete assignments; overcomes obstacles/adversities on the job, in garrison, and in the field. | | | Often volunteers to work extra hours; pushes on to overcome all difficulties and adversities until the job is done. |
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FOLLOWING REGULATIONS AND ORDERS:

How effective is each operator in adhering to regulations, orders, and SOP and displaying respect for superiors?

| Often fails to follow Army/unit rules, regulations, or orders; may show disrespect toward superiors. | Almost always follows Army/unit rules and regulations; always obeys orders. | Carefully follows the spirit and letter of Army/unit rules and regulations; obeys orders quickly and with enthusiasm. |
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INTEGRITY:

How effective is each operator in displaying honesty and integrity in job-related and personal matters?

| Makes up excuses to avoid duty/ assignments; fails to take responsibility for any job-related mistakes; may be untruthful about job or personal matters. | Admits and takes responibility for most job-related mistakes he/she makes; is truthful questioned about job or personal matters. | Takes extra steps to ensure that others are not blamed for his/her mistakes; is always honest, even when it may go against personal interests. |
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LEADERSHIP:

How effective is each operator in performing in a leader role, as required, and providing guidance for fellow unit members?

| Fail to take charge when leadership is required in unit; provides no guidance to other unit members on tasks, assignments, etc., even when it's necessary to do so. | Performs well in leadership situations where expected is well known; when asked, guides others through some tasks, assignments, etc. | Takes charge when necessary to lead the unit; fills in effectively when NCO is absent by skillfully leading unit, guiding unit members through tasks or assignments, etc. |
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MAINTAINING ASSIGNED EQUIPMENT:

How effective is each operator in checking on and maintaining own weapon/vehicle/other equipment?

| Keeps assigned equipment in poor condition by failing to perform or improperly performing checks and preventive maintenance. | Keeps assigned equipment in good condition by performing routine checks and preventive maintenance; notes and corrects major deficiencies. | Keeps assigned equipment in ready-for-inspection condition by performing appropriate checks and preventive maintenance, noting and correcting all deficiencies. |
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SELF-DEVELOPMENT:

How effective is each operator in developing own job skills?

| Does not try to improve job skills by studing, practicing, or participating in courses or training. | Practices, studies manuals, or participates in courses/training to improve job skills as required. | Studies, works hard during off-duty time, seeks out education or training, or additional job duties/responsibilities to improve job skills as much as possible. |
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SELF-CONTROL:

How effective is each operator in controlling own behavior related to aggresive acts?

| Often cannot control own behavior; loses temper easily. | Keeps even temper in most situations. | Always keeps a cool head and avoids aggressive acts. |
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| 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 13 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 14 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

ATTENDANCE:

How effective is each operator at reporting to the job on time and performing attentively?

| Is often late for "skeds"; makes frequent trips to the latrine; sometimes "sleeps" on the job. | Is usually on time for "skeds"; rarely "sleeps" on the job; infrequently schedules medical appointments during duty hours. | Is always on time for "skeds" and rarely absent for medical reasons; always attentive on the job. |
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| 13 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 14 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

ADMINISTRATIVE DUTIES:

How effective is each operator at completing forms and logs, and writing reports?

| Often intercept forms and logs, and written reports need to be altered by a supervisor; doesn't facilitate follow-up processing and analysis. | Completes intercept forms and logs, and reports with few errors; helps in facilitating follow-up processing and analysis. | Promptly completes intercept forms and logs, and reports without errors; often initiates the recording of data entries facilitating follow-up processing and analysis. |
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| 14 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

DATA ANALYSIS:

How effective is each operator in performing analysis?

| Often fails to notice irregularities of interest in performing the collector analysis; makes many computer generated errors that can be attributed to the operator. | Performs collector analysis adequately, often noticing suspect items of intelligence interest; makes few computer generated errors that can be attributed to the operator. | Completes collector analysis efficiently always noticing and promptly reporting suspect items of intelligence interest; rarely makes a computer generated error. |
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| 13 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 14 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

OPERATIONS:

How effective is each operator in performing job operations duties? #'s?????

| Often displays borderline (poor) performance standards for detecting, acquiring identifying, and recording foreign communications. | Almost always displays average/good performance in detecting, acquiring, identifying, and recording foreign communications. | Maintains excellent performance in detecting,acquiring identifying, and recording foreign communications; seems to have a natural "talent". |
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| 13 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 14 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

OVERALL EFFECTIVENESS RANKINGS:

Please rank order all of your operators from highest to lowest (with 1 representing the highest ranking) on their overall effectiveness, considering the above 12 dimensions.

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2 ---

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OVERALL EFFECTIVENESS RATINGS:

How does each of your operators individually rate on overall effectiveness, considering the above 12 dimensions?

| Performs poorly in important effectiveness areas; does not meet standards and expectations for adequate performance | Adequately performs in important effectiveness areas; meets standards and expectations for adequate performance. | Performs excellently in all or almost all effectiveness areas -exceeds standards and expectations for performance. |
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| 13 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 14 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 15 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

CONFIDENCE RATING:

For each operator, please indicate how confident you are with the effectiveness ratings that you just completed?

| | not at all confident | | moderately confident | | | very confident | |
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BISTA-WP-86-01

# Working Paper

## TEST-BED FOR HIGH INFORMATION-DENSITY DISPLAYS: A WAR-ROOM IN A TANK

Aaron Hyman, Ph.D.

Army Research Institute

DECEMBER 1986

U.S. Army Research Institute
for the Behavioral and Social Sciences
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# Test-Bed for High Information-Density Displays: A War-Room in a Tank

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U.S. Army Research Institute for the Behavioral and Social Sciences

## Problem Area

Due to technological advances, the complexity of the modern battlefield has grown enormously; and the amount of information, both obtainable and necessary to be dealt with, has expanded incredibly. Supporting displays, suitable for battlefield situation awareness and decision making, are now needed for effectively utilizing this increase in available information. However, because of workspace limitation, computer supported tactical displays have been designed to subtend a small visual angle; and when viewed at optimum distance, they present a relatively limited number of visually resolvable symbols and data. This often requires a sequential call-up of additionally wanted data, and taxes the user's memory when integration of non-simultaneously presented information is necessary. Hence as a further aid, some of the information is compressed into complex symbolic graphics which overlay the basic display; but these can clutter such a display and even obliterate or interfere with the legibility of the background presentation. A display configuration is required which permits a more natural human acquisition and processing of information, so there be more rapid situation understanding and decision making even in a high information-density environment. Other concerns with automated battlefield management are the retention of planning flexibility for the commander, and the enabling of a graceful degradation of operations when there is loss of information inputs from sources or from higher headquarters. To overcome these problems, a display interface is wanted which can properly present the volume of information, and has the flexibility to conform to each commander's strengths, limitations and changing needs in his acquisition and use of information. Then given the display interface, research is needed to determine the content, presentation, and interactive modes required for better supporting the commander in his undertakings.

Previously, the tactical commander had been presented with wall-mounted detailed maps that were overlayed with clear plastic sheets which could be marked (in grease pencil) with the plans for troop movement, enemy engagement, etc. The commander's decisions were based also on additional summary inputs, presented to him in oral briefings and in hard copy prepared by his staff, regarding such aspects as enemy intelligence, troop and equipment readiness, available combat support, available logistic support, weather, etc. Now, the relatively spacious work environment and easy opportunity for staff interaction disappears if the commander is to operate from computer supported tactical displays mounted in a mobile combat vehicle. One cannot put a war room into a space-limited tank, or can one? Is there a way to incorporate the best features of the old into the new tactical display interface?

## Purpose of Paper

There is need for developing a generic tactical display interface which will help overcome the problems raised in the previous section. This interface should have applicability to different levels of command and various workstation environments. It is the direct purpose of this paper to discuss the design of a test-bed representing a prototype of a high information-density display system that is feasible in a small space working environment. The test bed would permit making empirical comparisons and evaluations, in the present time-frame, of display alternatives that could be available and/or needed in near-future automated battlefield management systems.

## Design Approach

The designers of battlefield management systems that were to be mounted in combat vehicles had to restrict themselves to electronic information displays which occupy a modest amount of physical space. A common solution was to limit themselves to one or at most two displays, each having a resolution of about 500 x 500 picture elements (pixels). Because of the approach selected, the user is now forced to operate in an unfamiliar mode and in a manner which may not be optimum for human decision making. The amount of information to be presented at one time should really have been governed by such factors as comprehension rate, display access time, and the nature of human perception. If an observer is to respond quickly to new information, he does not have the time to comprehend dense informational detail. Also, if the display presents large amounts of rapidly changing overlay data, there may be further difficulty in comprehension. However, if the observer is permitted to view at will the aspects of interest to him on a visually expanded and hence less cluttered display, rather than being forced to sequentially request (in a confined window) the various data of interest, he can quickly concentrate on what is of concern now, and merely look elsewhere at a later time for what may be of concern then. This is a mode in which a human being has had extensive experience and can operate effectively. Thus using a design approach in which a large quantity of resolvable display information (suitably processed, condensed, and highlighted when so needed) is presented simultaneously on a number of contiguous screens, the observer can access different aspects of this information just by directing his attention to the appropriate sub-display area. Eye movement and head movement are extremely rapid motor responses which the observer can use as frequently as needed to obtain, in a non-disruptive manner, the information wanted for making comparisons and for augmenting the fundamental information on which he is basing his decisions.

## Proposed Configuration

Simultaneous presentation of a number of standard-sized electronic displays is readily possible if the work area in which they are being shown is physically large enough to contain them. How large does this have to be for the human viewer? Regarding the eye, angular subtense of the display is what matters and not just its physical size. A 3-inch

display viewed at 3 inches (with optical aiding) is equivalent to a 19-inch display viewed at 19 inches, and to a 10-foot display viewed at 10 feet. Each subtends an identical visual angle of approximately 53 degrees.

The average observer, with spectacle correction if needed, has about 20/20 Snellen visual acuity (i.e., his eye can resolve 1 arc minute). Let us assume, however, that our observer has slightly poorer visual acuity (e.g., he has a Snellen visual acuity of 20/30 and thus can visually resolve only 1.5 arc minutes). For a display subtending 120 degrees, such an observer could visually resolve about 4800 TV lines. That is to say this observer could adequately resolve all the details shown on eight CRT's placedside-by-side if each presented 600 resolvable picture elements on each of its horizontal raster lines. Thus if the displays generated by these eight CRT's were each 30 inches wide and placed on a circular arc having a 9.55-foot radius of curvature, they would subtend about 120 degrees at the center of this radius of curvature. Similarly, for eight contiguous images each subtending one inch, the subtense of the circular arc on which they are placed would now be about 120 degrees if viewing distance were 3.8 inches. While such viewing can be easily accomplished with the aid of a +10.37 diopter eyepiece, the instantaneous field of view provided by an optical eyepiece is not likely to be greater than about 50 degrees. This constraint can be overcome by dividing the 120-degree display into three sections each subtending 40 degrees. Viewing would be through an optical system in which multiple exit pupils are overlapped at the center of rotation of the viewing eye. One way to build such a display interface at the present time, is to use matrices of 1-inch CRT's such as Litton's L-4272 miniature cathode ray tube. These CRT's can each provide a rectangular image of 0.60" x 0.45" (for a 3 by 4 aspect ratio). A relay lens can then expand each image to 1.33" x 1.00" and, with appropriate mounting and baffling, contiguous images could be obtained for the units comprising a matrix. A segmented field lens placed in the image plane would then direct the light rays through the eyepiece to form a common exit pupil region for all CRT displays in the matrix (see Figure 1). Eye relief could be designed to be three inches. The separate sections, each comprised of a matrix of CRT's, could now be mounted so their eyepieces were contiguous and their exit pupils also overlapped. If color displays were desired, a field-sequential color system could be employed, utilizing the liquid-crystal shutter technology that is being developed by Tektronix.

A three section display as described above, and using folded optics, could be designed to occupy less than one cubic foot of volume. Hence such a display could be mounted in a tank or even on a jeep. The upcoming technology in miniaturized, high-resolution, flat color displays should permit an even simpler interface for multiple-screen displays in the future.

## Research Plan Concept

An initial concern is the establishment of the design requirements for miniaturized multiple screen displays. A follow-on concern is the determination of what should be the content, format, and interactive capa-

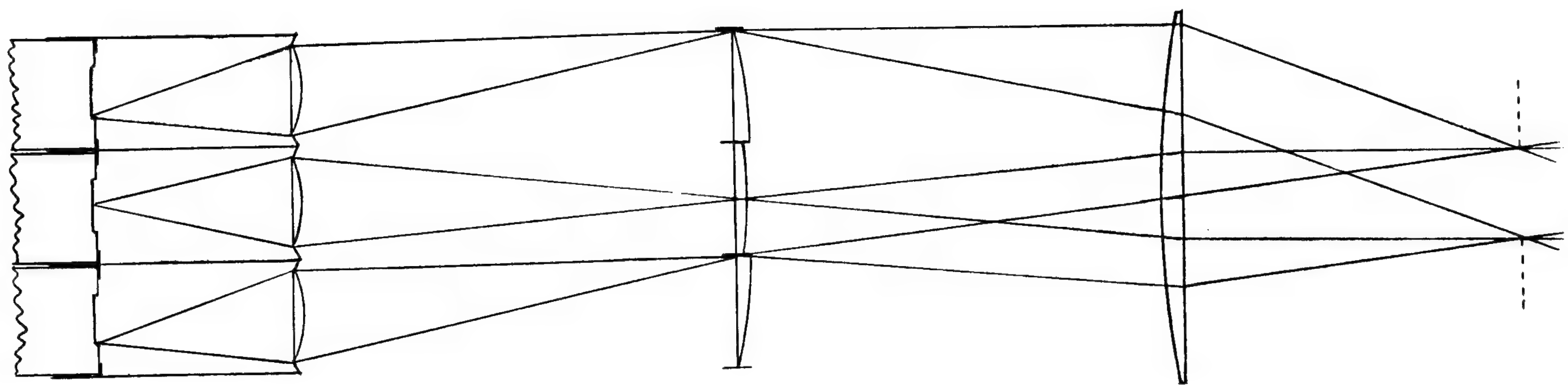


Figure 1
Schematic of the Lens System for One Section of the
Multiple-Screen Display

bilities appropriate for commanders in various echelons carrying out alternative missions and operating in different environmental situations. A suitable test-bed capable of being used both in the laboratory and in field exercises could be developed to aid in addressing the initial concern. Following this, a determination of the most suitable display content for selected military environments and scenarios could be made, using appropriate field trials.

An illustrative multiple-screen layout is shown in Figure 2. It is comprised of three sections. One presents the kind of information needed and organized for conducting tactical operations. Another provides real-time information obtained directly from battlefield sensors. The third presents related stored imagery, as would be obtained from earlier overflights by airborne and/or space vehicles. The first two have matrices of four CRT's; the third has a matrix of nine CRT's. Thus the total display is comprised of 17 CRT's. The commander interfaces interactively with these displays through such control devices as a trackball, a small digitizing pad, and/or function keys; and such aspects as cursor positioning, for example, would be accomplished through direct visual feedback of cursor location on the display.

In the Figure 2 illustration, each section subtends 40 degrees horizontally by 30 degrees vertically; but instead of the three sections being on a horizontal line, one is placed to the right of the central section, and the other is placed above it. Display content is meant to be illustrative only. Its specific nature should be developed through in-depth interviews with potential military users, and then evaluated in operational field tests, using an already developed display test-bed and associated supporting systems, hardware and software. It is the purpose of this paper to encourage initiation of activities leading to the development and use of such a display test-bed.

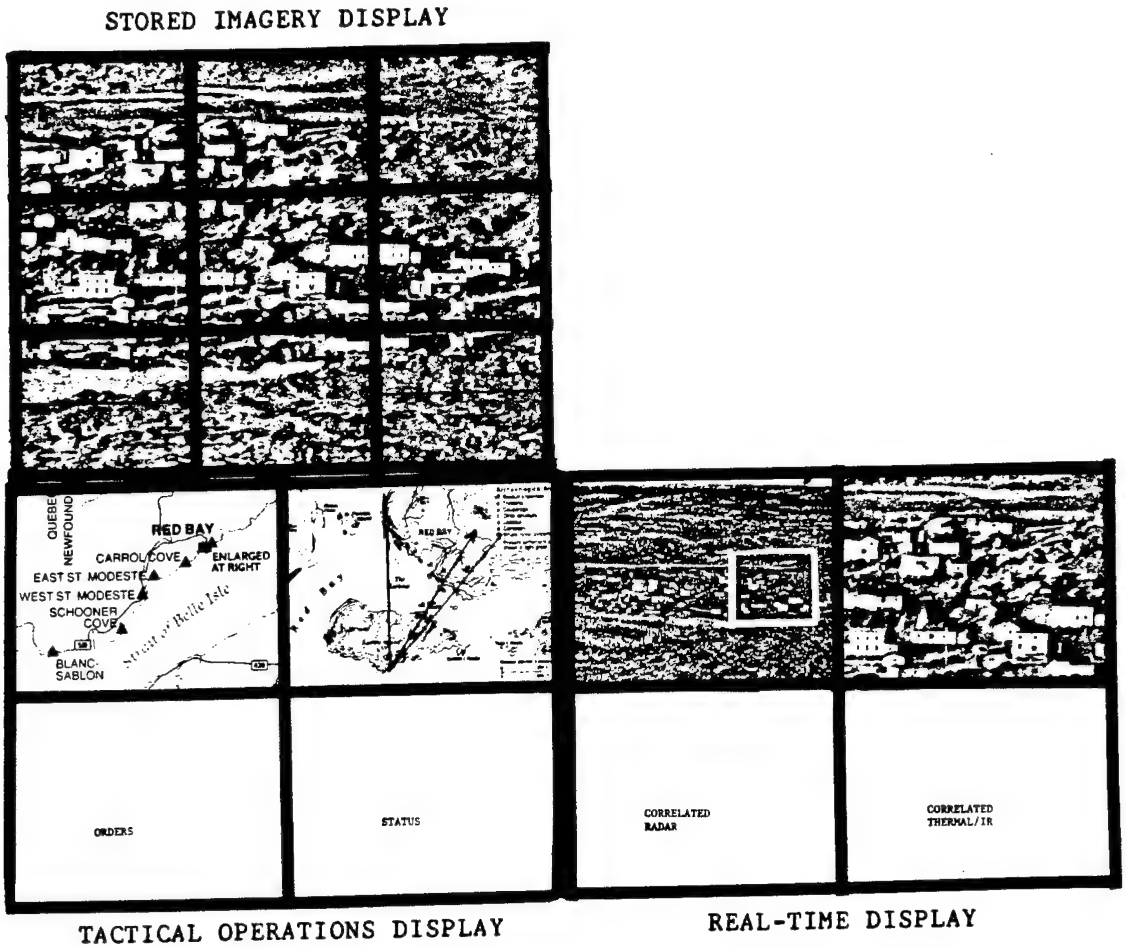


Figure 2
A Concept for a Display Interface for the Battlefield Commander

The total display is comprised of three sections, each subtending 40° horizontally and 30° vertically. The presented displays are meant to be illustrative only. The upper left section presents previously obtained reconnaissance imagery of an area of interest, selected by the commander, plus the surrounding eight neighboring images. These scenes have a 25% overlap. The lower left section is concerned with tactical operations. Starting at the upper left and going clockwise: the first sub-display provides input to the commander, using maps and graphics to give him processed combat information; the second is commander generated, also uses maps and graphics, and concentrates on the commander's sector of responsibility; the third lists the status of equipment and personnel; and the fourth presents incoming and outgoing orders. The lower right section presents real-time sensor information. Starting at the upper left and going clockwise: the first sub-display shows live video of his sector of responsibility and outlines a portion of the scene which he selects to view in magnification on the second sub-display; the third shows correlated thermal/IR imagery; and the fourth presents a correlated radar display.

# Working Paper 86-03

JSTARS MOS Analysis for Army Aircrew

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August 1986

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## Introduction

JSTARS (Joint Surveillance Target Attack Radar System) technology for wide area surveillance will be deployed in the 1990-92 timeframe. This new sensor capability provides a more accurate picture of moving and fixed targets with enhanced moving target indicator (MTI), fixed target indicator (FTI), and SAR (synthetic aperture radar) capability. The new technologies will concommitantly place new demands on MI (Military Intelligence) personnel.

Questions have been raised by the TSM-JSTARS regarding the appropriate Army crew composition and MOS-skill level for the JSTARS aircraft. At issue are the following: (1) How do the proposed requirements for the O & C (operations and control) console operator match the skills of the 96 CMF MOS's (96H, 96D, 96B) projected for this function ? What level of seniority is required ? (2) In addition to an O-3 or O-4 level Deputy Mission Crew Commander to represent the Army perspective and deconflict mission service requests, is a warrant officer (962) or senior NCO (96 series) required for supervisory functions and technical expertise ?

The following report describes the ARI analysis effort to provide input to the two issues above.

## Approach

The objective of the ARI analysis was to provide a database for use in estimating parameters such as task complexity, training demands, and other task qualifications in order to develop recommendations for the MOS which can best meet the JSTARS Army aircrew requirements. The approach taken consisted of several steps:

(1) Derive Army operator tasks proposed for the JSTARS aircrew; Develop basic JSTARS job flow

(2) Convert tasks to functions

(3) Breakout functions into human performance elements using generic table

(4) Assess cognitive demands for each function

(5) Develop comparison matrix of tasks to MOS capabilities and skill levels

(6) Derive tradeoffs

Each step is described below.

Army Operator Tasks for the JSTARS Aircrew

Data gathering to derive Army functions in the JSTARS aircraft involved eight document reviews and nine interviews with SME's (subject matter experts)

The documents reviewed were:

JSOC (Joint System Operational Concept) for JSTARS

US Army, Air Force Continue Development of Joint Stars; Aviation Week and Space Technology, 5 May 1986

Soldiers to Join JSTARS Tracking Crews Aloft; Army Times, 30 June 1986

Joint STARS Ground Station Module Brochure, Motorola 52597/1085-A, Oct 1985

Potential ATOC SEMBACH/Joint STARS Integration, hard copy brief by K.L. Leonard, MITRE Corp.

O & C Console System Specifications

Training and Training Equipment Plan for JSTARS Aircrew, Grumman Melbourne Systems, operating division of Grumman Corporation

Training course sequence for JSTARS GSM, hard copy briefs, training department, USAICS-DSSM

Subject matter experts interviewed were:

Maj Acker, Maj Tuttle, CPT Drain - TSM JSTARS

1LT(P) Watkins - JSTARS GSM training facility, USAICS-DSSM

Mr. Muckelroy, CPT Rust, CPT Droege, CPT Lemons- USAICS-CD Force Design Branch

Mr. Elliott, CW 2 Borgman - USAICS-CD M&L Air Branch

Mr. John Bloomfield, Mr. Tom Parker - Honeywell

Mr. Cliff Miller - MITRE/PM JSTARS

SFC Tilford - USAICS-DOTD New Systems

Ltc Fusco - Chief, USAICS-DSSM

Maj Huff - MILPERCEN

Based on the readings and extensive discussions with SME's, it was determined the the Army crew will consist of "two to five Army personnel on board the aircraft, with two to three per eight hour shift" (JSOC-JSTARS). This two to three man crew will consist of a Deputy Mission Crew Commander, and an Army radar system manager/operator(s).

The deputy mission crew commander is projected to be an O-3 or O-4

35C SSI (Special Skill Identifier). This individual is charged with the responsibility for liason to Air Force targeting and weaponeering activity, deconflicting radar service request from ground force commanders and GSM's, and performing decision and supervisory functions for Army personnel. The job clearly requires a minimum O-3 experience level with supervisory capability. Projected threat levels (per meeting with PM JSTARS/MITRE) indicate that the message and vehicle traffic will be very demanding so as to require over 50% of the deputy mission crew commander's time. This means that the individual must devote a large amount of time to deconflicting requests, setting priorities and making sure the Air Force usage of the beam, using the interleaved radar time line does not compromise Army needs. The net result is that very little time will be available to monitor routine matters engaged in by the radar system operators, and supervisory availability there will be minimal.

The radar system manager, or O & C console operator, have been assigned a number of functions related to the operation of the O & C console, management of the radar time line, tracking and reporting of targets, maintenance of computer data files, and preparation and dissemination of reports. The extent to which duties are designated to be performed by these individuals appears to vary according to the interpretation of the data gathered in the analysis. One of the consequences of the data gathering for this effort effected a tasking to the USAICS-CD to provide finer detail in the written specification of operator functional requirements for the Army air crew. This will be drafted at a later date as an annex to the O&O plan. A comprehensive list of operator tasks derived from the analysis is in Table 1.

The table indicates several natural groupings of tasks. Tasks 1-7 concern I-O operations of the O & C console according to specific radar service requests. Tasks 8-13 involve the Army radar system management and processing of multiple requests. Tasks 14-19 encompass situation assessment using wide area search and collation of MTI/FTI data to classify targets, develop relationships, and draw inferences about enemy intentions within a given sector or sub-sector. Finally tasks 20-23 engage the operator in the preliminary aspects of attack planning. In addition to the performance of

TABLE 1. ARMY AIRCRAFT TASKS USING O&C CONSOLE (AIRCRAFT)

1. O&C CONSOLE I-O OPERATIONS AND MAINTENANCE
2. IDENTIFY REQUESTED TARGETS FROM GROUND LEVEL SERVICE REQUESTS
3. SEARCH AND TRACK SPECIFIC TARGET
4. REPORT TARGETS AND TARGET PARAMETERS (LOCATION, LENGTH, SPEED)
5. PREDICT FUTURE MTI LOCATIONS USING F TRACK PROCESSING
6. MAINTAIN COMPUTER DATA FILE
7. ENTER FTI/SAR REQUESTS TO RADAR SYSTEM
8. MONITOR RADAR REQUEST TIME LINE
9. ACCEPT AND PROCESS RADAR STATUS MESSAGES
10. INFORM OPERATORS OF REQUEST STATUSES
11. COMPARE SERVICE REQUESTS TO RADAR TIMELINE STATUS
12. CONSOLIDATE SERVICE REQUESTS FOR EFFICIENT SYSTEM TASKING
13. ESTABLISH AND DELETE SPECIFIC RADAR COVERAGE AREAS TO BE SEARCHED
14. SELECT AND VIEW CURRENT RADAR DATA BY TYPE AND GEOGRAPHIC AREA
15. IDENTIFY SPECIFIC NON-REQUESTED TARGETS OF IMPORTANCE
16. REVIEW HISTORICAL RADAR DATA USING ACTIVITY INDICATORS, GROUND CLUTTER MAP, TARGET CLASSIFICATIONS FROM PREVIOUS FTI AND MTI DETECTION REPORTS, ETC.
17. MONITOR RADAR PATTERNS AND RELATIONSHIPS
18. CLASSIFY TARGETS OF INTEREST
19. PREDICT ENEMY INTENTIONS USING CLASSIFICATIONS
20. NOMINATE AND DESIGNATE TARGETS FOR ATTACK USING A TRACK PROCESSING
21. TRACK TARGETS
22. DESIGNATE ATTACK PLANNING AREAS AND ENGAGEMENT POINTS
23. ESTABLISH AND DELETE ATTACK PLANNING AREAS TO BE SEARCHED

these tasks, all crew members must be aviation qualified. High level job flow diagrams are presented in Figure 1. These show two discrete roles identified by task clusters, and list pertinent observations for each. For example, the first seven tasks are represented in the top diagram of the figure. These are equipment oriented, procedural tasks requiring perception of signals and psychomotor activity. Performance of these tasks requires system specific knowledge of the equipment at the operational and minimal maintenance levels. Diagrams below this indic... a more cognitively demanding set of tasks, which involve decision making and judgement, as well as the need for guidance and tasking from higher authority. The tasks also require the integration of background knowledge, expertise and experience. Tasks related to targeting (at the bottom of the diagram) could be considered an entirely separate function and would involve coordination with weaponeering elements of DIVARTY or the Air Force. The task list a... ...h flow diagrams clearly show a break into two discrete functions, poss... ...three.

## Convert tasks to functions

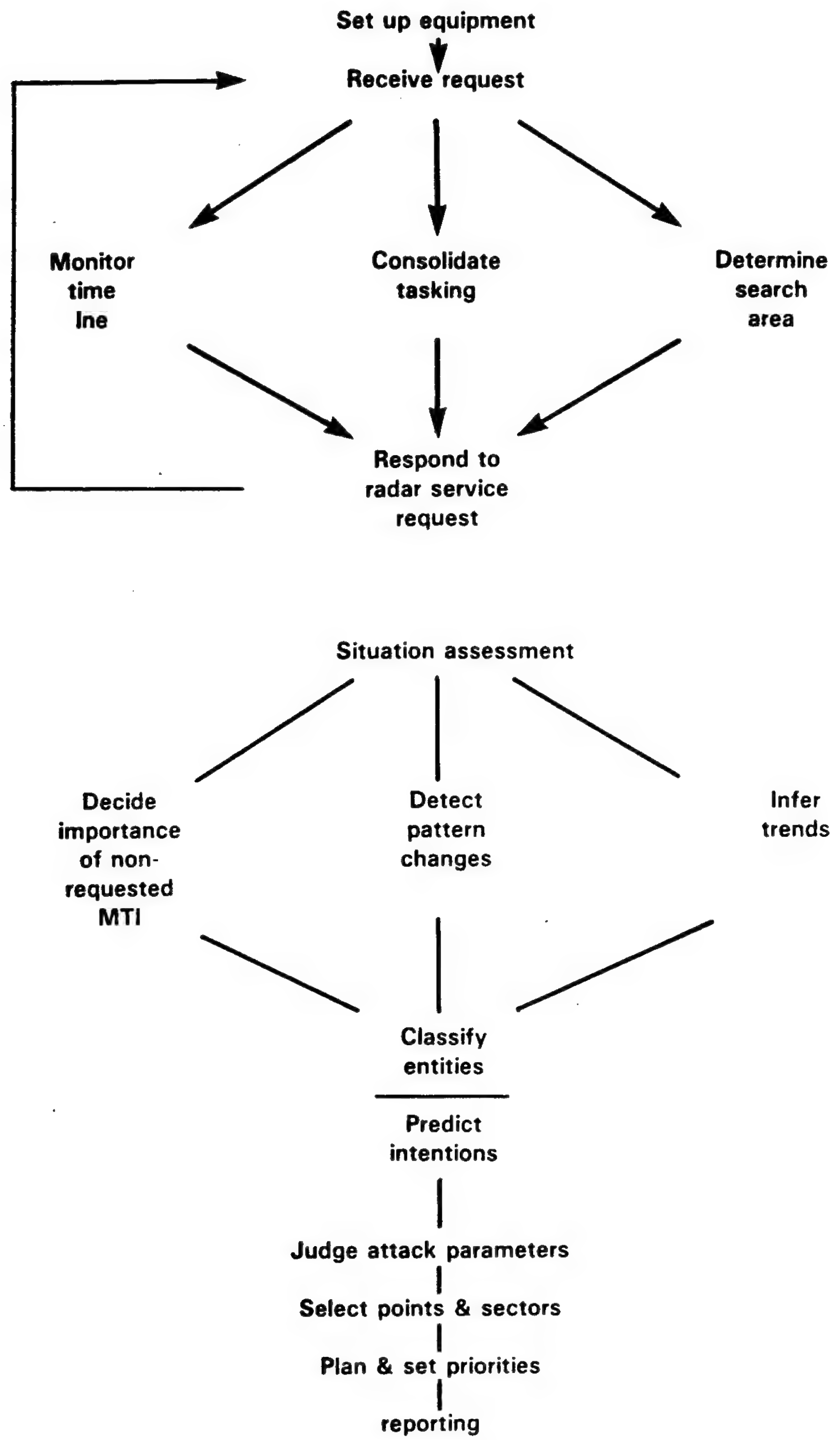
While the job tasks and flow diagrams indicate discrete operator roles, the task descriptors are too system specific to relate directly to functional qualifications of the MOS's being considered for the job. Therefore, the task list was converted to functions which are at a more generic system performance level. Table 2 presents the list of 23 functions derived from the original tasks of table 1.

## Breakout operator functions to human performance eleme... using generic table

The operator tasks and functions were next broken out in to human performance elements. That is, for each task or task aggregate, human performance components were determined which reflect the underlying sensory, motor, perceptual, or cognitive aspects of the task. These were based on a table of such elements, generated from larger taxonomies used in human performance studies. Table 3 shows the conversions of the JSTARS functions and Table 4 the generic human performance elements pertinent to them.

FIGURE 1.

**JSTARS JOB FLOW → OBSERVATIONS**




- Procedural, equipment oriented
- Context specific to radar system
- 96H-10 capable of all tasks with current training base

- Must depend on judgement and background knowledge and experience
- Tasks are cognitively demanding and not directly related to equipment at hand

- Targeting must be directed by higher authority
- Can be viewed as entirely separate function

- Job flow breaks out into two discrete functions, possibly three
- Indicates two very different operator roles, one at skill level 1, one at skill level 3 or 4

TABLE 2. BASIC FUNCTIONS FOR JSTARS OPERATOR USING
O&C CONSOLES ON AIRCRAFT

| ARMY AIRCRAFT TASKS USING O&C CONSOLE (AIRCRAFT) | BASIC FUNCTIONS |
|---|---|
| 1. O&C CONSOLE I-O OPERATIONS AND MAINTENANCE | 1. DATA TERMINAL OPERATIONS, MAINTAIN EQUIPMENT STATUS |
| 2. IDENTIFY REQUESTED TARGETS FROM GROUND LEVEL SERVICE REQUESTS | 2. IDENTIFY TARGET CLUSTERS, DATA TERMINAL OPS |
| 3. SEARCH AND TRACK SPECIFIC TARGET | 3. SEARCH AND TRACK, DATA TERMINAL OPS |
| 4. REPORT TARGETS AND TARGET PARAMETERS (LOCATION, LENGTH, SPEED) | 4. REPORT, DISSEMINATE VIA DATA LINK, RADIO; DATA TERMINAL OPS |
| 5. PREDICT FUTURE MTI LOCATIONS USING F TRACK PROCESSING | 5. DETERMINE IF PREDICTIVE INFO NEEDED, DATA TERMINAL OPS |
| 6. MAINTAIN COMPUTER DATA FILE | 6. DATA MANAGEMENT USING SYSTEM |
| 7. ENTER FTI/SAR REQUESTS TO RADAR SYSTEM | 7. DECIDE TO GIVE RADAR REQUESTS TO SYSTEM; DATA TERMINAL OPS |
| 8. MONITOR RADAR REQUEST TIME LINE | 8. MONITOR REQUESTS ON TIMELINE, (DETERMINE PRIORITY) |
| 9. ACCEPT AND PROCESS RADAR STATUS MESSAGES | 9. MONITOR RADAR BEAM (FIX FAULTY RADAR OPS), DATA TERMINAL OPS |
| 10. INFORM OPERATORS OF REQUEST STATUSES | 10. REPORT, DATA TERMINAL OPS |
| 11. COMPARE SERVICE REQUESTS TO RADAR TIMELINE STATUS | 11. DECIDE IF TIME TO SERVICE REQUESTS (TIME LABELING DONE) DATA TERMINAL OPS |
| 12. CONSOLIDATE SERVICE REQUESTS FOR EFFICIENT SYSTEM TASKING | 12. AGGREGATE REQUESTS, DATA TERMINAL OPS |
| 13. ESTABLISH AND DELETE SPECIFIC RADAR COVERAGE AREAS TO BE SEARCHED | 13. DETERMINE SEARCH AREA, DATA TERMINAL OPS |
| 14. SELECT AND VIEW CURRENT RADAR DATA BY TYPE AND GEOGRAPHIC AREA | 14. ESTABLISH CURRENT BASELINE PICTURE; DATA TERMINAL OPS |
| 15. IDENTIFY SPECIFIC NON-REQUESTED TARGETS OF IMPORTANCE | 15. IDENTIFY, DECIDE IMPORTANCE OF NONREQUESTED MTIs, DATA TERMINAL OPS |
| 16. REVIEW HISTORICAL RADAR DATA USING ACTIVITY INDICATORS, GROUND CLUTTER MAP, TARGET CLASSIFICATIONS FROM PREVIOUS FTI AND MTI DETECTION REPORTS, ETC. | 16. DATA MANAGEMENT USING SYSTEM, RECOGNITION OF PATTERNS, COMPARISON OF CURRENT AND HISTORICAL DATA, SITUATION ASSESSMENT |
| 17. MONITOR RADAR PATTERNS AND RELATIONSHIPS | 17. DATA MANAGEMENT; INFER RELATIONSHIPS BASED ON PATTERNS AND KNOWLEDGE |
| 18. CLASSIFY TARGETS OF INTEREST | 18. CLASSIFY ENTITIES |
| 19. PREDICT ENEMY INTENTIONS USING CLASSIFICATIONS | 19. PREDICT TRENDS |
| 20. NOMINATE AND DESIGNATE TARGETS FOR ATTACK USING A TRACK PROCESSING | 20. DETERMINE CANDIDATE TARGETS FOR ATTACK, DATA TERMINAL OPS |
| 21. TRACK TARGETS | 21. TRACK TARGETS, DATA TERMINAL OPS |
| 22. DESIGNATE ATTACK PLANNING AREAS AND ENGAGEMENT POINTS | 22. PLANNING, DATA TERMINAL OPS, REPORT |
| 23. ESTABLISH AND DELETE ATTACK PLANNING AREAS TO BE SEARCHED | 23. SET PRIORITIES, SEARCH AND TRACK, DATA TERMINAL OPS |

| Army Aircraft Tasks Using ORC Console (Aircraft) | Basic Functions | Human Performance Components |
|---|---|---|
| 1. ORC console I-O operations and maintenance | Data terminal operations, maintain equipment status | 1. Activate, adjust, manipulate objects (AAMO) |
| 2. Identify requested targets from ground level service requests | Identify target clusters, data terminal ops | 2. Detect, AAMO, enter data |
| 3. Search and track specific target | Search and track, data terminal ops | 3. Detect, track |
| 4. Report targets and target parameters (location, length, speed) | Report, disseminate via data link, radio; data terminal ops | 4. Enter data, speak |
| 5. Predict future MTI locations using F track processing | Determine if predictive info needed, data terminal ops | 5. Associate, AAMO |
| 6. Maintain computer data file | Data management using system | 6. Encode, enter data |
| 7. Enter FTI/SAR requests to radar system | Decide to give radar requests to system; data terminal ops | 7. AAMO |
| 8. Monitor radar request time line | Monitor requests on timeline, (determine priority) | 8. Track, AAMO |
| 9. Accept and process radar status messages | Monitor radar beam (fix faulty radar ops), data terminal ops | 9. Encode and decode, AAMO |
| 10. Inform operators of request statuses | Report, data terminal ops | 10. Enter data, speak |
| 11. Compare service requests to radar timeline status | Decide if time to service requests (time labeling done) data terminal ops | 11. Compare and associate, AAMO |
| 12. Consolidate service requests for efficient system tasking | Aggregate requests, data terminal ops | 12. Compare and associate, AAMO |
| 13. Establish and delete specific radar coverage areas to be searched | Determine search area, data terminal ops | 13. Compare and associate, AAMO |
| 14. Select and view current radar data by type and geographic area | Establish current baseline picture; data terminal ops | 14. Compare and associate, encode and decode, infer, AAMO |
| 15. Identify specific non-requested targets of importance | Identify, decide importance of nonrequested MTIs, data terminal ops | 15. Detect, estimate, infer, AAMO |
| 16. Review historical radar data using activity indicators, ground clutter map, target classifications from previous FTI and MTI detection reports, etc. | Data management using system, recognition of patterns, comparison of current and historical data, situation assessment | 16. Compare and associate, encode and decode, estimate and calculate, infer, AAMO |
| 17. Monitor radar patterns and relationships | Data management; infer relationships based on patterns and knowledge | 17. Compare and associate, infer, track |
| 18. Classify targets of interest | Classify entities | 18. Classification, infer, track |
| 19. Predict enemy intentions using classifications | Predict trends | 19. Estimate and calculate, evaluate options, predict |
| 20. Nominate and designate targets for attack using A track processing | Determine candidate targets for attack, data terminal ops | 20. Compare and associate, estimate, AAMO, evaluate |
| 21. Track targets | Track targets, data terminal ops | 21. Track, AAMO |
| 22. Designate attack planning areas and engagement points | Planning, data terminal ops, report | 22. Formulate plans, calculate, evaluate options, AAMO, speak |
| 23. Establish and delete attack planning areas to be searched | Set priorities, search and track, data terminal ops | 23. Compare and associate, track, AAMO |

Table 3. Human Performance Components of JSTARS Army ORC Console Functions on Board Aircraft

TABLE 4. HUMAN PERFORMANCE ELEMENTS. PSYCHOMOTOR ELEMENTS ARE GENERALLY LESS DIFFICULT AND COMPLEX THAN EITHER SENSORY-PERCEPTUAL OR COGNITIVE; COGNITIVE ELEMENTS ARE MOST DIFFICULT AND COMPLEX OVER SENSORY-PERCEPTUAL

| | Difficulty and Complexity |
|---|---|
| (1) Psychomotor | |
| Activate (buttons, switches) | Lo |
| Adjust - Discrete (knobs, dials) | ↓ |
| Adjust - Continuous | ↓ |
| Manipulate objects | ↓ |
| Enter data | ↓ |
| Write | ↓ |
| Speak (transmit) | High |
| (2) Sensory-Perceptual | |
| Detection | Lo |
| Tracking | ↓ |
| Discrimination | ↓ |
| Classification | High |
| (3) Cognitive | |
| Compare and associate | Lo |
| Encode and decode | ↓ |
| Formulate plans (project actions) | ↓ |
| Evaluate options | ↓ |
| Estimate, calculate | ↓ |
| Predict, infer | High |

From the human performance literature, it is known that tasks expressed in behavioral terms can be assessed according to difficulty, complexity, and time to learn (as well as other parameters). These types of assessments are ratings based on knowledge of human sensory, perceptual and cognitive capabilities. A recent example of this type of assessment process was the development of the workload analysis for the Army aircrew cockpit database for the LHX (Light Helicopter Experimental), in which workload estimates were derived in order to determine the need for one or two Army crew members during specific missions (Anacapa Sciences, Inc., Oct 1984). In this work, judgements of parameters were based on mental processing steps and capacity of humans. For example, response to sensory stimulation (target detection) is a simple processing function involving discrimination of a signal from noise. This is known to be of low complexity and humans are relatively good at it at low to mid noise levels, or high noise levels where the sensory system has adapted the display background to their functioning. Identification of a target (assigning a name) is of greater perceptual difficulty. Even more complex is target classification which involves making inferences, drawing relationships, and planning. Comparing one thing to another is considered of low level complexity, and humans excel at this. As shown in Table 4, the human performance elements are listed in order of low to high difficulty and complexity, showing that psychomotor tasks are less difficult than sensory-perceptual, and cognitive tasks require maximum mental effort. One caveat is that psychomotor tasks involve an initial high cognitive demand during learning phase which quickly drops when the procedure becomes automatic.

## Assess cognitive demands for each function

Using the human performance elements table as a guide, the cognitive demands for each function were assessed. That is, for a particular function such as data terminal operations, this consists of three performance elements - activate, adjust, manipulate objects. These are psychomotor and of low difficulty and complexity. Therefore the cognitive demand to perform the task is low. This procedure was used to develop cognitive demands for all STO functions. The resulting Table 5 shows this assessment. It is immediate-

TABLE 5. JSTARS ARMY AIRCREW FUNCTIONS WITH CONCOMITANT COGNITIVE DEMANDS

| BASIC JSTARS FUNCTION | HUMAN PERFORMANCE ELEMENT | COGNITIVE DEMAND |
|---|---|---|
| 1. DATA TERMINAL OPS, MAINTAIN EQUIPMENT | ACTIVATE, ADJUST, MANIPULATE OBJECTS (AAMO) | LO |
| 2. IDENTIFY TARGET CLUSTERS DATA TERMINAL OPS | DETECT, AAMO, ENTER DATA | LO |
| 3. SEARCH AND TRACK, DATA TERMINAL OPS | DETECT TRACK | LO |
| 4. REPORT, DISSEMINATE VIA DATA LINK, RADIO; DATA TERMINAL OPS | ENTER DATA, SPEAK | LO |
| 5. DETERMINE IF PREDICTIVE INFO NEEDED, DATA TERMINAL OPS | ASSOCIATE, AAMO | MEDIUM |
| 6. DATA MANAGEMENT USING SYSTEM | ENCODE, ENTER DATA | MEDIUM |
| 7. DECIDE TO GIVE RADAR REQUESTS TO SYSTEM; DATA TERMINAL OPS | AAMO | LO |
| 8. MONITOR REQUESTS ON TIMELINE, (DETERMINE PRIORITY) | TRACK, AAMO | LO |
| 9. MONITOR RADAR BEAM (FIX FAULTY RADAR OPS) DATA TERMINAL OPS | ENCODE AND DECODE, AAMO | MEDIUM |
| 10. REPORT, DATA TERMINAL OPS | ENTER DATA, SPEAK | LO |
| 11. DECIDE IF TIME TO SERVICE REQUESTS (TIME LABELING DONE) DATA TERMINAL OPS | COMPARE AND ASSOCIATE, AAMO | LO |
| 12. AGGREGATE REQUESTS, DATA TERMINAL OPS | COMPARE AND ASSOCIATE, AAMO | LO |
| 13. DETERMINE SEARCH AREA, DATA TERMINAL OPS | COMPARE AND ASSOCIATE, AAMO | LO |
| 14. ESTABLISH CURRENT BASELINE PICTURE; DATA TERMINAL OPS | COMPARE AND ASSOCIATE, ENCODE AND DECODE, INFER AAMO | MEDIUM |
| 15. IDENTIFY, DECIDE IMPORTANCE OF NONREQUESTED MTIs; DATA TERMINAL OPS | DETECT, ESTIMATE, INFER | HIGH |
| 16. DATA MANAGEMENT USING SYSTEM, RECOGNITION OF PATTERNS | COMPARE AND ASSOCIATE, ENCODE AND DECODE, ESTIMATE AND CALCULATE, INFER, AAMO | HIGH |
| 17. DATA MANAGEMENT; INFER RELATIONSHIPS BASED ON PATTERNS AND KNOWLEDGE | COMPARE AND ASSOCIATE, INFER, TRACK | MEDIUM |
| 18. CLASSIFY ENTITIES | CLASSIFICATION, INFER TRACK | HIGH |
| 19. PREDICT TRENDS | ESTIMATE AND CALCULATE, EVALUATE OPTIONS, PREDICT | HIGH |
| 20. DETERMINE CANDIDATE TARGETS FOR ATTACK, DATA TERMINAL OPS | COMPARE AND ASSOCIATE, ESTIMATE, AAMO, EVALUATE | HIGH |
| 21. TRACK TARGETS, DATA TERMINAL OPS | TRACK, AAMO | LO |
| 22. PLANNING, DATA TERMINAL OPS, REPORT | FORMULATE PLANS, CALCULATE EVALUATE OPTIONS, AAMO, SPEAK | HIGH |
| 23. SET PRIORITIES, SEARCH AND TRACK, DATA TERMINAL OPS | COMPARE AND ASSOCIATE, TRACK, AAMO | MEDIUM |

ly obvious that cognitive complexity increases in relation to the break points in operator roles previously identified in the job flow diagrams of figure 1.

## Comparison of MOS capabilities and skill levels to demands of each function

The three MOS's under consideration for the JSTARS O & C control operator and radar system manager are 96H (Aerial Intelligence Specialist), 96D (Imagery Interpreter), and 96B (Intelligence IPB Analyst). Table 6 presents a compilation of the critical task areas or task aggregates for each MOS and skill level. These were aggregated from the approved approved critical task lists (Dec 85-Jan 86 timeframe) and from SME interviews. Using table 6 as a guide, Table 7 was developed which shows the capability of the MOS's as trained and by skill level, to meet the demands of each of the functions. Several points are immediately notable from the data of table 7:

- 96H-10 is well qualified for radar system terminal operation functions and low level system management functions, which equate to tasks 1-13 (given JSTARS equipment familiarization)
- Radar surveillance management, situation assessment functions (tasks 14-23) require operator capability at
  96H-40
  96D-30
  96B-20/30
  levels
- 96D and 96B MOS currently are not oriented toward data terminal operations and procedures. Their already lengthy resident training (compared to 96H) would have to be extended for system specific ASI as well as ADP knowledge and the aviation qualification
- A 96H training upgrade would be required to develop analytical functions for individuals to perform JSTARS system management and situation assessment through resident training
- Targeting functions, if appropriate for the function, require 96B type of training

## Discussion: Analysis and tradeoffs

One JSTARS scenario involves two operators, one concerned with processing radar service requests and managing the time line (O & C console operator), and a higher level person (radar system manager), viewing current and historical wide area search data and providing valued input to the Deputy Mission Crew commander and the GSM operators and commmanders. This scenario

TABLE 6: MOS TASK AGGREGATES OF QUALIFICATIONS AND SKILL LEVELS DERIVED FROM CRITICAL TASK LISTS (EXCLUDING COMMON SOLDIER TASKS)

| | 96H | 96D | 96B |
|---|---|---|---|
| SKILL LEVEL 1 | 1. PLAN SPECIFIC SURVEILLANCE MISSION (SLAR, IR, PHOTO)<br>2. IDENTIFY & PLOT TARGETS<br>3. PERFORM SYSTEM MAINTENANCE CHECKS<br>4. PERFORM OPERATIONAL CHECKS<br>5. PREPARE TERMINAL FOR OPS<br>6. OPERATE TERMINAL<br>7. IDENTIFY & PLOT TARGETS ON DISPLAY<br>8. PREPARE TERMINAL FOR DISPLAY<br>9. PERFORM MAINTENANCE CHECKS<br>10. AVIATION QUALIFICATIONS | 1. PHOTOGRAMMETRY: DETERMINE DISTANCES<br>2. IDENTIFICATION: IDENTIFY ENTITIES<br>3. ANALYSIS: USE IMAGERY ANALYSIS PRINCIPLES; ANALYZE SECTORS USING IR, RADAR<br>4. MISSION PLANNING: PREPARE SITMAP & OVERLAY DETERMINE IMAGERY COVERAGE; GIVE AIRCREW BRIEF<br>5. PREPARE REPORTS & BRIEFS PER SOP | 1. REVIEW INTEL HOLDINGS<br>2. PREPARE FRAG OR STAFF ORDER<br>3. MAINTAIN LOGS & WORKBOOKS<br>4. PREPARE SITMAPS & OVERLAYS<br>5. INTEGRATE NEW DATA<br>6. ASSIST IN BRIEFS |
| SKILL LEVEL 2 | 1. SUPERVISE PROCEDURAL TASK PERFORMANCE OF SKILL LEVEL TASKS 1-9 | 1. MISSION PLANNING: USE R&S CAPABILITIES FOR PLANNING SELECT ZONES OF ENTRY<br>2. PHOTOGRAMMETRY: MEASURE OBLIQUE & PANORAMIC IMAGES | 1. IDENTIFY PIR/IR PER MISSION<br>2. DETERMINE PIR/IR INDICATORS<br>3. DRAFT INTEL ESTIMATE<br>4. DEVELOP TEMPLATES & MATRICES<br>5. PROVIDE REAR AREA SECURITY |
| SKILL LEVEL 3 | 1. SUPERVISE OVERALL MISSION PLANNING FOR SLAR, IR, PHOTO<br>2. SELECT SITE FOR DATA TERMINAL DEPLOYMENT | 1. COLLECTION MANAGEMENT: PLAN GFR MISSION; BRIEF MISSION TEAM; PREPARE R&S PLAN; PREPARE & PROCESS AS&R REQUEST RELATE OTHER "INTS" TO IMINT: RECEIVE & REVIEW & DISSEMINATE MISSION RESULTS<br>2. IMAGERY ANALYSIS: PERFORM OVERALL ANALYSIS OF GROUND FORCES QUALITY CHECK IMAGERY REPORTS & ANALYSES | 1. MONITOR COLLECTION EFFORTS<br>2. EVALUATE REPORTS<br>3. COORDINATE INTEL PRODUCTION<br>4. ANALYZE FFFI<br>5. DEVELOP TARGET DATA |
| SKILL LEVEL 4 | 1. DIRECT TRAINING FOR TASKS IN SKILL LEVELS 1-3<br>2. MANAGE PERSONNEL ASSETS<br>3. MANAGE OV-LD/RV-ID S&R ASSETS<br>4. COORDINATE COMMO WITH OTHER NODES<br>5. KEEP MISSION STATUS LOG<br>6. INPUT TO CONTINGENCY PLANS<br>7. COMPARE R&S CAPABILITY TO POTENTIAL TARGETS | 1. SUPERVISE R&S PLAN PREPARATION<br>2. COORDINATE COLLECTIONS WITH OTHER NODES<br>3. REVIEW ADP FILES FOR INPUT TO IMAGERY DATABASE | 1. SUPERVISE UNIT<br>2. SUPERVISE ORGANIZATION OF OB DATA<br>3. TEMPLATE THREAT COLL ASSETS<br>4. DIRECT UNIT DUTIES<br>5. DEVELOP TARGET PARAMETERS FOR COLLECTION<br>6. COORDINATE TARGET FUNCTIONS |

TABLE 7. MOS SKILL LEVEL REQUIRED TO PERFORM JSTARS ARMY AIRCREW FUNCTIONS

| JSTARS Army Aircrew Function | MOS Skill Level Required 96H | 96D | 96B |
|---|---|---|---|
| 1. DATA TERMINAL OPERATIONS, MAINTAIN EQUIPMENT STATUS | 1 | 0 | 0 |
| 2. IDENTIFY TARGET CLUSTERS, DATA TERMINAL OPS | 1 | 0 | 0 |
| 3. SEARCH AND TRACK, DATA TERMINAL OPS | 1 | 0 | 0 |
| 4. REPORT, DISSEMINATE VIA DATA LINK, RADIO; DATA TERMINAL OPS | 1 | 1 | 1 |
| 5. DETERMINE IF PREDICTIVE INFO NEEDED, DATA TERMINAL OPS | 1 | 1 | 1 |
| 6. DATA MANAGEMENT USING SYSTEM | 1 | 0 | 0 |
| 7. DECIDE TO GIVE RADAR REQUESTS TO SYSTEM; DATA TERMINAL OPS | 1 | 0 | 0 |
| 8. MONITOR REQUESTS ON TIMELINE, (DETERMINE PRIORITY) | 1 | 0 | 0 |
| 9. MONITOR RADAR BEAM (FIX FAULTY RADAR OPS), DATA TERMINAL OPS | 1 | 0 | 0 |
| 10. REPORT, DATA TERMINAL OPS | 1 | 1 | 1 |
| 11. DECIDE IF TIME TO SERVICE REQUESTS (TIME LABELING DONE) DATA TERMINAL OPS | 1 | 0 | 0 |
| 12. AGGREGATE REQUESTS, DATA TERMINAL OPS | 1 | 0 | 0 |
| 13. DETERMINE SEARCH AREA, DATA TERMINAL OPS | 1 | 0 | 0 |
| 14. ESTABLISH CURRENT BASELINE PICTURE; DATA TERMINAL OPS | 0 | 1 | 1 |
| 15. IDENTIFY, DECIDE IMPORTANCE OF NONREQUESTED MTIs, DATA TERMINAL OPS | 4 | 3 | 3 |
| 16. DATA MANAGEMENT USING SYSTEM, RECOGNITION OF PATTERNS, COMPARISON OF CURRENT AND HISTORICAL DATA, SITUATION ASSESSMENT | 0 | 3 | 2 |
| 17. DATA MANAGEMENT; INFER RELATIONSHIPS BASED ON PATTERNS AND KNOWLEDGE | 3 | 1 | 1 |
| 18. CLASSIFY ENTITIES | 0 | 1 | 1 |
| 19. PREDICT TRENDS | 3 | 3 | 2 |
| 20. DETERMINE CANDIDATE TARGETS FOR ATTACK, DATA TERMINAL OPS | 0 | 0 | 3 |
| 21. TRACK TARGETS, DATA TERMINAL OPS | 1 | 0 | 0 |
| 22. PLANNING, DATA TERMINAL OPS, REPORT | 0 | 0 | 4 |
| 23. SET PRIORITIES, SEARCH AND TRACK, DATA TERMINAL OPS | 0 | 0 | 4 |

NOTE: A zero in the MOS skill level column indicates no current MOS capability to perform the function based on resident and unit training

assumes that the Army will have access to two or more data terminals on board the aircraft. It further assumes that the Deputy Mission Crew commander (officer level) will be only a casual user of the terminal. At the operator level, the performance of the 23 or so functions can be more than adequately handled by the 96H MOS, one at a skill level two, and one at a higher, experienced NCO level. Assignment of the higher level analytical and management functions to the 96D or 96B MOS's requires significant broadening of their already high level technical expertise in the imagery interpretation areas and analysis areas, respectively. The add on skills for the 96D and 96B would involve learning radar terminal I-O, aviation qualification, and database management. This would add significant time on to their already lengthy resident training. Certainly the 96B should be eliminated from consideration since this would be diverting the individual from the broad scope analytical training to a very system specific sole source context.

A second scenario, which would place more interpretive and analytical demands on the O & C console operator and radar system manager, would involve both individuals in mostly decision making activities for predictive intelligence and targeting. Based on this analysis, a senior NCO in the 96H track can adequately perform these duties. There is no significant difference in the skills developed by a 96H NCO (skill level 30 or 40) and a 962 WO for the duties, so it is cost effective to stay within the 96H track. The 96 enlisted crew member will be used as a valued source for data, which will prioritized by the deputy mission crew commander and transmitted via the SCDL near real-time down links to the ground forces commanders and GSM's. If this second scenario is strongly projected, the use of the 96D may need to be considered. The tradeoff between the 96H and the 96D does not seem worth it since the senior 96H has demonstrated the capability to pick up these functions through OJT, aviation, and combat experience. It seems that the best solution is to provide realistic JSTARS scenario types of stimulations to the junior and senior level 96H, in a CPX and FTX environment, as part of the transition of the 96H restructure from SLAR to JSTARS. This argues for a training upgrade of the 96H POI, in order to develop, in resident training, the qualified senior level analytical skills acquired OJT in current practice.

## Summary of Overall Findings

- Deputy Mission Crew Commander must be 35C O-3 or O-4 level individual to represent Army perspective to AF operations of JSTARS
- 96H-20 is well qualified for O & C control operation functions with only JSTARS specific equipment familiarity
- Radar system management and situation assessment functions currently demand a 96H-40, 96D-30 or 96B-20/30.
- 96H training upgrade in analytical skills would develop qualified senior level personnel sooner
- 96D JSTARS training on data terminal and aircraft would lengthen already extensive resident training base by at least 10 weeks
- 96 level WO not required in lieu of senior 96 NCO since no significant difference exists in these capabilities as required by JSTARS O & C operations or radar system manager functions
- Targeting functions may suggest need for 96B with ASI JSTARS, but this will lengthen extensive analytical training to a specific equipment context, and spread MOS definition and management very thin

ARI-BISTA

# Working Paper 87-01

JSTARS GROUND STATION MODULE MOS ANALYSIS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## Introduction

Joint STARS (Joint Surveillance Target Attack Radar System) is a Corps and Division level battlefield sensor system designed to detect, locate, and track moving ground targets located beyond the forward edge of the battlefield. Data is transmitted from airborne systems to ground station modules located at various points in support of Corps, Division, and Brigade level operations. A single ground display station is known as a ground station module (GSM). Currently the GSM is configured for a two person primary crew, with an additional two workstations for radio-telephone operations and a backup workstation. The GSM is being projected for near 24 hour operations, necessitating three primary crews: one per 8 hour shift per GSM.

In preparation for GSM deployment, certain issues have been raised by the Office of Chief Military Intelligence (OCMI), and the TSM-JSTARS, regarding the MOS and skill level appropriate to comprise the primary crew. First, what MOS(s) should be assigned to each primary crew ? Second, what skill level is the minimum requirement for each operator position within the primary crew ? Third, should the primary crew composition vary according to GSM, i.e., differ if the GSM is Corps support, Division support, Brigade support, or Artillery TOC support ? The following report describes the Army Research Institute (ARI) analysis conducted to provide input to OCMI and TSM-JSTARS in order to address the three issues.

Prior to presentation of the ARI analysis and findings on the GSM crew MOS issues, a number of qualifications are put forth:

Although a number of 96CMF personnel are currently being trained in the JSTARS-GSM training facility, the MOS's under consideration for the BOIP (Basis of Issue Plan) are 96D (Imagery Interpreter) and 96H (Aerial Intelligence Specialist).

Current force allocations and availability of 96D and 96H personnel may

change and evolve during the timeframe when JSTARS is fully deployed. Therefore analyses presented are neither governed nor constrained by existing personnel pool.

Training for the 96CMF is evolving due to enhanced laboratory capability expected in the Department of Surveillance and Systems Maintenance (DSSM). The analyses presented do not presume to represent changes in skill acquisition that will result in the future POI(program of instruction).

## Approach

The approach taken in the ARI analysis of GSM primary crew MOS issues consisted of a step by step compilation of task, functions, and skill demands projected for the operator positions in the GSM, followed by a matching process to relate the system demands to current MOS capabilities. Data gathering consisted of document reviews and interviews with subject matter experts (SME's) to derive system requirements. Following this a task and function listing was developed and matched to MOS descriptions provided by critical task lists, soldier's manuals, and AR 611-201. Human performance capabilties to perform functions were taken from psychological literature indicating task difficulty, complexity, and cognitive demand. The results of the analysis is presented below.

## Data gathering on GSM operator requirements

SME's from the TSM-JSTARS (CPT Drain) and PM JSTARS -Army (Mr. Dave Usachek, Deputy PM) were interviewed. In addition, detailed review was conducted of the JSTARS ROC (Required Operational Capability), A level system specification, Downsized GSM A specification, and GSM Operations Menu specification. Also, recent articles such as "Integrated Radar Expected to Be Operational by 1990's" (ARMY TIMES, OCT 20, 1986), and similar write ups in the ARMY GREEN BOOK (1985-86), were noted. The system capabilities allow for operator workstations to accomodate the following positions:

TSS - Target Surveillance Supervisor
STO - Search Track Operator

RTO - Radio Telephone Operator

A single GSM configuration consists of one TSS and one STO, with RTO while a dual full crew GSM consists of one TSS, two STO's and one RTO per workstation. The single GSM configuration, with two operator primary crew, is the core of any given shift's operations. The system will not allow login to exceed the possible positions available, that is the dual GSM configuration would accept only two STO logins and then require a TSS and RTO to follow. The single GSM configuration allows for a TSS and STO as primary crew.

The GSM is primarily conceived to process MTI (moving target indicator) data, however advanced concepts indicate possible integration of data from other IMINT sources (such as electro optical, infrared), or even corollary SIGINT sources. This would mean receipt and processing of data from other sensors either on separate or split screen, or integrated into the MTI data base for call up. Also, the threat projections provide a busy picture of MTI data alone during scenarios in certain circumstances. Given this data, it is clear that manipulation of MTI data is only a part of the overall GSM mission. Table 1 is a list of task categories and subtasks as derived for operators in the GSM primary crew. It is immediately obvious that there is a progression of tasks from simple data terminal operations (Tasks 1-5), to file creation and review for battle management and targeting activities (Tasks 6-10). In addition, coodination and supervisory tasks are critical to the overall workflow since it will be virtually impossible to focus on a single MTI processing task and simultaneously assess total target priorities and patterns from a larger perspective (Tasks 11-16). Also, the GSM, having many data links to other C3I nodes, requires the bigger picture perspective at all times for coodinations and efficient use of data. A STO is likely to spend the majority of the shift on the primary data terminal operations (Tasks 1-7), and only situation coordination interface functions as backup in a degraded mode. Figure 1 graphically presents a single GSM workflow,

Table 1. JSTARS GSM tasks for TSS, STO, and RTO

1. Power up and operate console workstation - logon and status checks
2. Establish appropriate communications network(s)
3. Task sensor beam via data link to sensor platform
4. Locate and identify specific MTI's according to tasking
5. Search and track specific MTI's
6. Manipulate data in assigned area of operations
    a. Operate display scale, recenter capability
    b. Review masked areas
    c. Operate time compression and time integration modes
    d. Develop and maintain graphic overlays
7. Develop target files
    a. Identify targets of interest
    b. Store/display targets
    c. Predict target characteristics - e.g. location, speed
    d. Autotrack selected targets

8. GSM system management
    a. Develop target status, summary files
    b. Correlate GSM data into message data log from TACFIRE, SIGMA, etc.
9. Integrate and interpret alternative sensor source data (UAV, IR, etc.)
    a. Accept and review single sensor (non-MTI) data files
    b. Select and display multisensor inputs (split screen, dual screen)
    c. Create integrated situation database
    d. Develop predictive intelligence
    e. Develop specific target parameters
10. Message processing
    a. Formulate messages according to prescribed formats
    b. Develop message logs
    c. Transmit messages
11. Coordinate data files with other GSM data in AO

12. Review data files of STO terminal(s)
13. Review STO target files
14. Develop expanded target summary files
15. Assign target priorities
16. Predict target parameters

17. Display I/O messages
18. Display system equipment statuses of subsystems
19. Formulate and transmit communication messages
20. Maintain master message log

Figure 1. Workflow Diagram for JSTARS GSM

STO

Power up operator workstation

Establish communication net

Respond to requests for search and taskings

Battle management

Manipulate data

Targeting

Identify targets of interest

Develop files

Track events

STO/TSS

Correlate Data with other ground sources

GSM's, TACFIRE, SIGMA

Integrate and interpret alternative sensor data

UAV, IR, SIGINT

Develop overall situation database

Message processing

Formulate messages

Log messages

Transmit messages

STO/TSS

Relate GSM data to other message data files

TSS

Supervise individual operator data processing

Review imagery files

Decide importance of non requested MTI's

Review target files

Develop expanded target summaries

Assign target priorities

Predict target parameters

RTO

Display I/O messages

Display system equipment statuses of subsystems

Maintain master message log

showing the progression from STO to TSS tasks. An overlap of responsibility is apparent in the transition from tasks 8-11, that is, no indication is obvious which are purely STO and which are purely TSS. The RTO function (Tasks 17-20), is presented at the bottom for completeness although not considered part of the two person primary crew.

## Analysis of GSM task demands

The GSM task list of Table 1 was converted to functions as shown in Table 2. This provided a basis to decompose functions into human performance components. From these, tasks were assessed for mental (cognitive) complexity and difficulty. Table 3 shows the STO and TSS functions expressed in their underlying human performance components. Human performance literature indicates that functions, such as data terminal operations, analysis of entities, report preparation, etc. consist of a finite set of behaviors that range from simple psychomotor tasks to complex mental calculations and searches. A set of these behaviors is listed in Table 4, showing the range from the simple to the complex, and the categories of each. The four categories show that level of difficulty increases from simple psychomotor tasks to complex cognitive interactive tasks. For example, detection of a target on a screen is a perceptual task of low difficulty for a human, while prediction of intention is a complex cognitive task requiring extensive mental work. Note that supervisory work is distinguished from individual cognitive tasks in that it involves interpersonal activities and decision making of an even greater cognitive complexity than that for a single individual.

Using tables 3 and 4 as a guide, the cognitive demands for the GSM functions were assessed. That is for a particular function, such as data terminal operations, this consists of three human performance elements - activate, adjust, manipulate objects. These are psychomotor and of low difficulty and complexity. Therefore the cognitive workload for the task

Table 2. Basic Functions of JSTARS GSM Operators

| Task # | Function |
| --- | --- |
| 1 | Data Terminal Operations, maintain equipment status |
| 2 | Radio and digital data link operations |
| 3 | Data Terminal Operations |
| 4 | Identify target clusters, data terminal operations |
| 5 | Search and track, data terminal operations |
| 6 | Determine appropriate search windows, decide situation parameters, review and compare, data terminal operations |
| 7 | Identify targets, determine target parameters, identify target characteristics, determine importance of selected targets, track selected targets, data terminal operations |
| 8 | Data management using system: Aggregate past data, correlate various sources, data terminal operations |
| 9 | Review non-MTI data, compare inputs, create new situation display |
| 10 | Receive new data, develop data transaction log, transmit messages, data terminal operations |
| 11 | Decide importance and relationship of correlary GSM data to current A/O database |
| 12 | Review and monitor STO data processing - battle management |
| 13 | Review and monitor STO data processing - targeting |
| 14 | Develop candidate high priority targets |
| 15 | Prioritize targets |
| 16 | Predict target intentions |
| 17 | Operate RTO screen |
| 18 | Review and monitor eqiupment operations |
| 19 | Communicate with outside entities - Radio + equipment ops |
| 20 | Maintain accurate message log |

Table 3. Human Performance Components of JSTARS GSM Functions

| Task and Function # | Human Performance Component |
|---|---|
| 1 | Activate, adjust, manipulate objects (aamo) |
| 2 | Aamo |
| 3 | Enter data, transmit |
| 4 | Detect, track, aamo |
| 5 | Track, aamo |
| 6 | Evaluate options, compare and associate, estimate, manipulate objects |
| 7 | Detect, calculate, discriminate, infer, track, aamo |
| 8 | Compare and associate, encode and decode, aamo |
| 9 | Compare and associate, encode and decode, infer, classify, predict, aamo |
| 10 | Detect, compare and associate, transmit |
| 11 | Compare and associate, infer, interact with higher authority |
| 12 | Review procedural tasks, review results, monitor progress, aamo |
| 13 | Review procedural tasks, review results, monitor progress, aamo |
| 14 | Decide importance of results |
| 15 | Prioritize results |
| 16 | Predict, infer |
| 17 | Aamo |
| 18 | Aamo, compare |
| 19 | Enter data, transmit |
| 20 | Aamo, enter data |

Table 4. Human Performance Elements

| TYPE | DIFFICULTY + COMPLEXITY |
|---|---|
| **PSYCHOMOTOR** | |
| Activate (buttons, switches) | LO |
| Adjust - discrete (knobs, dials) | ↓ |
| Adjust - continuous | ↓ |
| Manipulate objects | ↓ |
| Enter data | ↓ |
| Write | ↓ |
| Speak (transmit) | HIGH |
| **SENSORY-PERCEPTUAL** | |
| Detection | LO |
| Tracking | ↓ |
| Discrimination | ↓ |
| Classification | HIGH |
| **COGNITIVE - INDIVIDUAL** | |
| Compare + Associate | LO |
| Encode + Decode | ↓ |
| Formulate Plans (Project actions) | ↓ |
| Evaluate options | ↓ |
| Estimate, calculate | ↓ |
| Predict, infer | VERY HI |
| **COGNITIVE - INTERPERSONAL + SUPERVISORY** | |
| Review procedural tasks | MODERATE |
| Review results of actions | ↓ |
| Monitor progress | ↓ |
| Decide importance of results | ↓ |
| Prioritize findings | ↓ |
| Interact with higher authority | VERY HI |

Note: Psychomotor elements are generally less difficult and complex than either sensory-perceptual or cognitive; cognitive elements are most difficult and complex over sensory.

is low. Table 5 shows the breakout of functions by cognitive demand. The STO tasks (1-7), are clearly less demanding than those of the TSS (11-16), and if both operator roles are critical to GSM operations, than at least one of each will be required per GSM per shift to insure accomplishment of the workflow. The overlap or transition tasks (8-11), require a higher skill level STO or a dedicated TSS with deemphasis on supervisory activity.

## MOS capability comparison to GSM demands

Two MOS's are under consideration for assignment to the GSM STO and TSS positions: 96D and 96H. Table 6 is a digest of critical task aggregates representing acquired skills as trained and developed in resident and unit experience. Common soldier skills and aviation training (96H) are not included. With the task aggregates of Table 6, Table 7 was developed matching GSM demands to available skills and skill levels within the two MOS's. The numbers in the MOS columns indicate skill level required to perform the functions, and a zero indicates that the MOS as trained is not equipped to perform the function.

## Discussion: Analysis of findings

Table 7 reveals the capability of 96H 10 and 20 to perform only minimal functions within the GSM (Tasks 1-6). Although both 96H 10 and 20 have worked with MTI data in current operations, the performance of the function is more equipment oriented than analysis oriented. Few specific analysis skills are trained in the current 96H track, and senior level 96H (30 and 40) possess these skills only incidentally through combat experience situations. Senior level 96H personnel are provided supervisory training, however, and it is evident that their ability to coordinate findings and make decisions is part of becoming an NCO. The 96D individual is more capable at a lower skill level, to assume the tasks of the STO for the Tasks 6-11, within the GSM. With the projected activity level for any given workstation

Table 5. Cognitive demands of JSTARS GSM Functions

| Task # | Function | Cognitve Demand |
|---|---|---|
| 1 | Data Terminal Operations, maintain equipment status | LO |
| 2 | Radio and digital data link operations | LO |
| 3 | Data Terminal Operations | LO |
| 4 | Identify target clusters, data terminal operations | LO |
| 5 | Search and track, data terminal operations | LO |
| 6 | Determine appropriate search windows, decide situation parameters, review and compare, data terminal operations | MODERATE |
| 7 | Identify targets, determine target parameters, identify target characteristics, determine importance of selected targets, track selected targets, data terminal operations | HIGH |
| 8 | Data management using system: Aggregate past data, correlate various sources, data terminal operations | MODERATE |
| 9 | Review non-MTI data, compare inputs, create new situation display | VERY HI |
| 10 | Receive new data, develop data transaction log, transmit messages, data terminal operations | MODERATE |
| 11 | Decide importance and relationship of correlary GSM data to current A/O database | HIGH |
| 12 | Review and monitor STO data processing - battle management | VERY HI |
| 13 | Review and monitor STO data processing - targeting | VERY HI |
| 14 | Develop candidate high priority targets | HIGH |
| 15 | Prioritize targets | HIGH |
| 16 | Predict target intentions | HIGH |
| 17 | Operate RTO screen | LO |
| 18 | Review and monitor eqiupment operations | LO |
| 19 | Communicate with outside entities - Radio + equipment ops | LO |
| 20 | Maintain accurate message log | LO |

Table 6. MOS Task Aggregates of Qualifications and Skill Levels, derived from AR 611-201, critical task lists, and other sources (excluding common soldier tasks) for 96H and 96D.

| 96H | 96D |
|---|---|
| **Skill Level 1** | **Skill Level 1** |
| Plan specific surveillance mission (SLAR, IR, PHOTO) | Photogrammetry: determine distances<br>Identification: identify entities |
| Visually acquire targets<br>Identify and plot targets | Analysis: use imagery analysis principles to analyze sectors using IR, Radar |
| Perform system maintenance checks | Mission Planning: prepare sitmap and overlays<br>Determine imagery coverage<br>Give aircrew brief |
| Data terminal operations: | |
| Prepare terminal for ops<br>Operate terminal<br>Identify and plot targets<br>Prepare terminal for display<br>Perform maintenance checks | Obtains information of intel value<br>Prepares reports and briefs per SOP |
| Aviation qualifications<br>Interpret threat to aircraft<br>Performs radio communications | |
| **Skill Level 2** | **Skill Level 2** |
| Supervise procedural task performance on Skill level 1 tasks | Mission planning:<br>Use R&S capabilities for planning<br>Select zones of entry |
| Assist imagery analyst | Prepares and maintains enemy sitmap<br>Determines physical features of terrain and enemy installations,deployments, weapons, equipment, defenses, commo |
| | Photogrammetry: measure oblique and panoramic images |
| | Studies and analyzes imagery produced by aerial sensors systems |
| **Skill Level 3** | **Skill Level 3** |
| Supervise overall mission planning for SLAR, IR, PHOTO | Collection management:<br>Plan GSR mission, brief mission team<br>Prepare R&S plan, process AS&R request |
| Select site for data term | Relate other "INTS" to IMINT |

deployment

Assist in plan and manage of aerial surveillance systems

Assist imagery analyst in enemy parameter id

Conducts sit briefs to cdr

Skill Level 4

Supervise overall tasks of skill levels 1-3:
Assign duties, schedule
Supervise operations of section
Review and critique mission results of section

Direct training for tasks in skill levels 1-3

Manage OV-1D/RV-1D S&R assets

Coordinate commo with other nodes

Keep overall mission status log

Advise cdr on interface of aerial surveillance with ground surveillance

Receive and review and disseminate mission results

Imagery analysis:
Perform overall analysis of ground forces
Quality check imagery reports and analyses of subordinates

Prepares and maintains target folders

Skill Level 4

Supervise R&S Plan preparation

Coordinate collection with other nodes

Review ADP files for input to imagery database

Instructs subordinates in proper techniques and procedures for II

Performs secondary quality control of II analysis to determine accuracy validity, completeness

Assists in planning for utilization of air and ground R&S sensor systems

Table 7. JSTARS GSM Functions X MOS Capability

| Task # | Function | MOS Skill Level Requirement 96H | 96D |
|---|---|---|---|
| 1 | Data Terminal Operations, maintain equipment status | 1 | 0 |
| 2 | Radio and digital data link operations | 0 | 0 |
| 3 | Data Terminal Operations | 1 | 0 |
| 4 | Identify target clusters, data terminal operations | 1 | 0 |
| 5 | Search and track, data terminal operations | 1 | 0 |
| 6 | Determine appropriate search windows, decide situation parameters, review and compare, data terminal operations | 2 | 1 |
| 7 | Identify targets, determine target parameters, identify target characteristics, determine importance of selected targets, track selected targets, data terminal operations | 0 | 2 |
| 8 | Data management using system: Aggregate past data, correlate various sources, data terminal operations | 0 | 2 |
| 9 | Review non-MTI data, compare inputs, create new situation display | 0 | 3 |
| 10 | Receive new data, develop data transaction log, transmit messages, data terminal operations | 1 | 2 |
| 11 | Decide importance and relationship of correlary GSM data to current A/O database | 4 | 3 |
| 12 | Review and monitor STO data processing - battle management | 3 | 3 |
| 13 | Review and monitor STO data processing - targeting | 3 | 3 |
| 14 | Develop candidate high priority targets | 4 | 3 |
| 15 | Prioritize targets | 3 | 3 |
| 16 | Predict target intentions | 0 | 3 |
| 17 | Operate RTO screen | 1 | 0 |
| 18 | Review and monitor eqiupment operations | 1 | 0 |
| 19 | Communicate with outside entities - Radio + equipment ops | 1 | 0 |
| 20 | Maintain accurate message log | 1 | 0 |

Note: A zero in the MOS column indicates no present capability of the MOS as trained to perform the function

within the GSM network, it appears that the knowledge of enemy order of battle, battlefield entities and patterns, and integration of this with the emerging MTI picture, is more adeptly handled by the 96D. It is important to note that the current training of the 96D is not system specific nor equipment oriented (Tasks 1-5). This means that attention will have to be devoted to this in GSM training. While on the surface it appears that the 96D is the obvious choice for GSM operations, both in the supervisory and operator positions, final judgement rests on acceptance of which of two scenarios is most likely: One JSTARS scenario projects use of MTI data as the primary mission and function of the GSM, and that other input sources are secondary or conjecture for planning purposes. In this case, since the 96H has to date worked with a radar terminal dedicated to this MTI medium (Tasks 1-5), it is possible that the training to be provided in the GSM trainer could introduce and enhance analytical skills (Tasks 6-10) needed to function in the fielded GSM environment. Certainly the seasoned 96H NCO could adapt to the demands of the TSS tasks (11-16) and perform interface and decision making functions as prescribed. An assumption is made that the training in the GSM trainer will provide sufficient realistic, scenario-based stimulation to engender the required skills in battle management and targeting. A second scenario holds that the fielded JSTARS GSM will be an advanced technological workstation processing multiple IMINT and possibly SIGINT inputs in an integrated way. This will mean that a 96D would certainly be best equipped to go beyond simple identifications and transmissions (STO Tasks 1-7) and interject considerable analysis of battlefield entities and target situations (STO-TSS Tasks 8-11). Although considerable time and effort is spent in providing training to 96D personnel which allow for analysis and predictive capability, the individuals are not particularly equipment oriented or geared toward a radar workstation environment. Again, the POI within the GSM training facility provides this, however it is an add on to their already lengthy and difficult resident training. It appears

that the question is whether to add the difficult analytical skills to lower level 96H personnel or add data terminal operation system-specific skills to the 96D AIT curriculum. Once the supervisory level is reached, the NCO of either track (96H30 or 96D30) is suitable.

## Conclusions and recommendations

Returning to the MOS issues raised in the introductory section of this report, several questions were raised. The conclusions reached are based on the necessity for the primary crew to consist of at least one STO and one TSS in order to perform the system functions. The preceding analysis and discussion leads to the following conclusions:

1) MOS Assignment to primary crew per shift - The 96D 20 is recommended to perform the STO tasks to include data manipulation required for tasks 1-10. A 96D 30 TSS should be available on all shifts to accomplish the higher level tasks 11-16. The 96H does not currently have the skills to manage the critical operator tasks 8-11 which are required. Only an intensive training and simulation environment could hope to cultivate the required skills and reorient the POI of the 96H to a more analytical base.

2) Minimum skill level requirement for each position -
STO: skill level 20; TSS: skill level 30. Could exceed in each case but this would be a misuse of personnel for any given shift. If a higher level TSS skill level 40/50 is available for cross shift personnel management, and co-performs TSS single shift duties, this is a different matter.

3) Crew composition by GSM (Division, Corps) - Since threat projections indicate a busy environment for the Division but an even busier role for the Corps, a back up STO (skill level 20) is recommended for the Corps level GSM, not additional supervisory personnel. This is because the work within the GSM is primarily workstation oriented, and concerns manipulation of data at a terminal, which is then overseen and findings prioritized by a supervisor. One NCO per shift and more operators who develop initiative and proficiency is the most efficacious crew model.